STUDIES ON THE COTTON JASSID (EMPOASCA DEVASTANS DISTANT) IN THE WESTERN PUNJAB. XIII. METHOD OF COTTON BREEDING FOR JASSID RESISTANCE

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INTRODUCTION

Almost all the workers on the cotton jassid in the world are of the opinion that hairiness and jassid resistance are closely linked together. Macdonald, Ruston and King (1943), summarizing all the previous work done in South Africa, have stated that there exists a very close relationship between hairiness and jassid resistance. The other literature bearing on this point has been fully reviewed in a previous paper (Afzal and Abbas, 1943) and will not be repeated here. It was also pointed out that all previous work suffered from the serious flaw that linkage of the two characters had been sought from the study on pure breeding varieties. Genetic linkage can, however, be only fully appreciated from a study of hybrid progenies. A few results of this study have already been reported (Afzal and Abbas, 1943) and it has been shown that the two characters were closely linked. In these studies the plants were classified simply by eye observation into resistant and susceptible groups. These studies were, thus, of a qualitative nature. It was, however, realized that it would be much better to study these characters quantitatively by actually counting the number of eggs laid on the plants with varying degree of hairiness as it is now known that resistance to jassid is really resistance to oviposition only and the eggs once laid even in the leaf-veins of immune varieties of *arboreum* cotton have no difficulty in hatching out and developing into adults (Verma and Afzal, 1940). The correlation of various plant characters should, therefore, be worked out with resistance to oviposition. Investigations in this direction were carried out at Lyallpur during 1943 and the results of these observations are reported here.

MATERIAL AND METHOD

For these observations the following two 4th generation hybrid progenies, which were split for hairiness were selected:

(1) Progeny No. 204 of (920 Cambodia × 58 F) 289F/43.

(2) Progeny No. 226 of (920 Cambodia × 58 F) 124F.

There were 38 plants in Progeny No. 204 and 37 in Progeny No. 226 available for these observations. As the progenies were split for hairiness, plants of all shades of hairiness from sparsely to profusely hairy, were represented within these progenies.

The actual counting of the eggs laid in the leaf-veins could be carried out only by dissecting the leaf-veins which necessitated the plucking of the leaves. This method was, therefore, not employed. On the contrary, the oviposition was studied indirectly by counting the freshly hatched nymphs on all leaves of all the plants on alternate days. All the nymphs were killed and removed from the leaves by means of a camels-hair brush. These observations were continued throughout the period of severe jassid infestation *i.e.*, from the 10th August to the end of September.

The extent of hairiness was determined by counting, under a binocular, the total number of hairs on one centimeter length of each of the three prominent leaf-veins from the pulvinus spot of the leaf. These observations were taken from the fully formed primary leaves of the 20th, 25th, 30th and 35th nodes from each plant.

The toughness of leaf-veins was studied by means of a special apparatus designed for the purpose (Ahmad, Afzal and Ghani, in press). The toughness was measured in the c.c. of water required to be displaced by puncturing a particular vein by means of a needle. As in the case of hairiness, the toughness was also determined from all the primary leaves available on the main stem of each plant from the 20th to the 45th nodes. It was recorded from the mid-rib of each leaf at a distance of one centimeter from the pulvinus spot.

DATA AND RESULTS

The total nymphal population, mean hairiness and toughness of leaf veins of all the plants of the two progenies under observation are given in Table I.

Table I

Nymphal population and mean hairiness and toughness in hybrid progenies

Plant No.	Progeny 204			Progeny 226		
	Population	Hairiness	Toughness	Population	Hairiness	Toughness
1	256.83	9.67	56.00	77.83	36.25	67.10
2	133.46	116.58	85.08	77.25	183.75	71.39
3	139.21	156.83	80.71	155.04	21.92	66.33
4	115.66	87.33	79.19	110.88	49.67	69.56
5	237.41	24.75	48.92	119.67	27.75	64.36
6	136.62	52.58	80.72	115.08	34.17	63.80
7	202.66	30.33	59.29	68.04	232.67	65.90
8	266.08	11.92	55.44	67.92	45.83	61.15
9	118.96	96.25	73.72	81.17	61.50	57.58
10	62.08	107.25	66.89	59.54	160.42	67.92
11	123.00	70.00	76.19	110.67	21.75	60.15
12	57.67	82.92	72.75	108.38	20.58	60.50
13	62.25	130.75	67.25	69.54	44.00	48.72
14	302.62	5.08	55.60	94.58	36.50	58.14
15	174.33	6.92	51.50	45.13	195.42	66.94
16	118.37	129.58	77.89	114.67	38.00	53.73
17	184.33	151.17	67.06	121.88	15.33	61.85
18	214.66	104.00	70.75	49.54	190.08	62.00
19	171.16	12.67	56.63	97.54	35.50	74.29
20	50.29	148.00	62.00	105.33	33.50	66.13
21	135.21	109.33	72.50	62.54	122.58	67.00
22	112.00	112.83	74.50	62.33	161.33	69.00
23	94.12	79.50	67.69	58.13	182.50	64.13
24	58.29	103.50	68.70	43.42	180.92	70.55
25	127.33	105.92	68.75	77.54	24.33	61.00
26	158.83	98.33	59.00	103.92	34.67	52.29
27	60.62	84.25	70.36	54.67	142.75	61.61
28	88.83	86.00	81.25	82.42	50.67	60.67
29	79.08	114.75	63.70	113.46	37.33	65.42
30	46.25	117.83	62.50	116.04	37.00	69.25
31	79.75	79.75	78.96	45.21	208.25	65.61
32	65.67	191.92	76.10	41.33	199.92	68.00
33	94.96	97.83	72.33	107.67	30.42	58.83
34	84.25	106.33	71.67	59.83	224.75	70.79
35	70.54	123.25	79.00	84.92	47.00	70.40
36	205.83	7.17	56.86	75.42	75.33	63.45
37	68.71	109.58	65.00	42.04	194.50	66.58
38	103.50	128.42	82.81			

From the figures given in Table I, an attempt was made to find out the correlations of the three factors, namely, oviposition, hairiness and toughness. These correlations are discussed below:

(i) *Hairiness and toughness*

Progeny 204 $r = +0.6050$ Significant at 1%.
Progeny 226 $r = +0.4022$ Significant at 5%.

These correlations were positive and significant in both the progenies, showing thereby that the more the number of hairs on a leaf-vein, the tougher its veins were likely to be or in other words hairiness and toughness went together.

(ii) *Toughness and jassid population*

Progeny 204 $r = -0.5295$ Significant at 1%.
Progeny 226 $r = -0.1899$ Non-significant.

This correlation was significant only in the case of one progeny and its validity should, therefore, be considered somewhat doubtful. The negative nature of this correlation in both the progenies, however, indicated that the population had a tendency to decrease as the toughness increased.

(iii) *Hairiness and jassid population*

Progeny 204 $r = -0.6873$ Significant at 1%.
Progeny 226 $r = -0.8108$ Significant at 1%.

This correlation in both the progenies was negative and highly significant. This shows that the more hairy plants had definitely a smaller population than the less hairy ones.

In order, however, to find out the inter-relationship of these three characters—population, toughness and hairiness partial regressions were worked out, as it is only by this method that the actual relationship can be determined.

(iv) *Partial regressions of toughness and population by keeping the hairiness as constant*

Progeny 204 $r = -0.1966$ Non-significant.
Progeny 226 $r = +0.2542$ Non-significant.

Thus it appears from the above that toughness alone played a very insignificant part in determining the jassid population on a plant. Moreover, it has to be conceded that delicate measurements of toughness will not prove of much benefit to the cotton breeder unless such measurements can be made very rapidly.

Table II

Hairiness and Jassid population in hybrid progenies

Hairiness (Class intervals)	Population (Class intervals)								
	0–30	30.1–60	60.1–90	90.1–120	120.1–150	150.1–180	180.1–210	210.1–240	240.1 & above
0– 20					1*	2	1		3
20.1– 40			1*	13*		1*	1	1	
40.1– 60			5*	1*	1				
60.1– 80			1 2*	1	1				
80.1–100		1	2	2	1	1			
100.1–120		1	4	1	3			1	
120.1–140		1	2 1*	2					
140.1–160		1 1*			1		1		
160.1–180			1*						
180.1–200		6*	1 1*						
200.1–220		1*							
220.1–240		1*	1*						

Note:—The figures starred indicate the number of plants of Progeny 226, while others that of Progeny 204.

The breeder has to deal with literally thousands of plants in a short space of time and it is necessary that some easily recognizable morphological character of the plant associated with jassid resistance should be found.

Painter (1943) is of the opinion that hardness of tissue as a cause of resistance is open to question, but that differences in plant structure may be found to be genetically linked with resistance and may hence prove to be useful marks in the search for resistance. The toughness of the cuticle of the leaf-vein of cotton is, perhaps, a character which is not the primary cause of resistance but only an indication of it.

(v) *Partial regressions of hairiness and population by keeping the toughness as constant*

Progeny 204 $r = -0.5434$ Significant at 1%.
Progeny 226 $r = -0.8171$ Significant at 1%.

Both these regressions were negative and highly significant showing thereby that as the hairiness increased the jassid population decreased.

The behavior of different plants in the two progenies, as regards hairiness and population can be more clearly studied from Table II.

It will be observed from Table II that, on the whole, progeny 204 was more hairy than 226, though the plants with the largest number of hairs were met with in progeny 226. The population showed a definite decrease with the increase in hairiness. The most important point to be noted from this table, however, is that in both the progenies, with the exception of two plants in Progeny 204, almost all the plants with more than 120 hairs per centimeter length of the leaf-vein, had very small jassid populations and hence may be considered as resistant. It may now, however, be stated that if a cotton breeder selects plants with more than 120 hairs per centimeter length of the leaf-vein, an overwhelming majority of these will be resistant to the attack of jassids. Thus hairiness has proved to be a most important and easily recognizable morphological character associated with jassid resistance on which a breeder can rely for the selection of resistant varieties with a fair amount of certainty.

EFFECT OF ARTIFICIAL REMOVAL OF HAIR ON JASSID OVIPOSITION

Although hairiness has been shown to be highly correlated with resistance, there is still some doubt regarding the nature of this interdependence. If hairiness as a physical character of the plant, was inhibiting oviposition and was thus directly linked with resistance when the artificial removal of hair from the leaf-vein should render the plant susceptible. That this is not so has been shown by the following experiment.

The experiment was carried out for the first time in 1943 when the jassid population in the fields was fairly high. Four plants of 199 F, a hairy and resistant variety were encaged in removable muslin cages ($2\frac{1}{2}' \times 2\frac{1}{2}' \times 4'$). After 5–6 days the cages were removed and all the nymphs present on the leaves were killed and removed. This was done to allow sufficient time for the eggs, if any were laid before the commencement of

Table III

No. of nymph hatching on shaved and unshaved leaves, 1943

Date of observation	Shaved leaves		Unshaved leaves	
	No. of leaves	No. of nymphs	No. of leaves	No. of nymphs
30.VIII	39	25	43	26
2.IX	30	26	40	14
4.IX	30	10	40	6
6.IX	27	34	41	55
8.IX	27	25	37	16
10.IX	25	5	35	7
14.IX	94	69	90	48
16.IX	99	90	93	69
18.IX	97	38	88	35
20.IX	95	4	91	8
22.IX	89	15	79	21
24.IX	88	11	82	24
27.IX	82	8	80	13
29.IX	80	16	75	22
Total .	902	376	914	364
Average No. of nymphs per leaf.		0.417		0.398

the experiment, to hatch out. The hairs from the prominent veins of the alternate leaves of the each plant were removed by means of safety razor blades, taking care not to injure the cuticle. The shaved leaves were tagged to distinguish these from the unshaved ones. The cages were then removed to allow free access to the jassids. The oviposition on the shaved and unshaved leaves was then studied as already described. The data obtained are presented in Table III.

The experiment was repeated in 1944 and the data are given in Table IV.

Table IV

No. of nymphs hatching on shaved and unshaved leaves, 1944

Date of observation	Shaved leaves		Unshaved leaves	
	No. of leaves	No. of nymphs	No. of leaves	No. of nymphs
9.VIII	88	23	92	20
11.VIII	82	44	84	45
13.VIII	87	62	88	57
15.VIII	72	53	76	63
18.VIII	80	76	74	56
20.VIII	52	47	51	56
22.VIII	41	36	46	45
24.VIII	46	36	42	41
Total	548	377	553	383
Average No. of nymphs per leaf.		0.688		0.693

From Tables III and IV it is abundantly clear that the removal of hairs made no difference in jassid oviposition. It may, therefore, he stated that the physical presence of hair on the leaf-vein does not induce resistance. It, therefore, appears highly likely that, as hairiness is closely associated with toughness, the combined effect of these two characters renders a plant resistant. It is also within the limits of possibility that some other character (moisture contents of the leaf-vein for example) may also be associated with these two characters. From the plant breeders point of view, however, it is enough to know

that hairy plants are resistant to the attack of jassids and the present work has been useful in settling all the previous doubts (Afzal, Husain and Lal, 1940), regarding the utility of this character, at rest. It is, therefore, now suggested that in areas where jassids are a serious menace, the plant breeder should select plants with more than 120 hair per centimeter length of the leaf-vein. It cannot, however, be expected of the breeder to actually count the number of hairs on the leaf-veins of all the plants he is dealing with, and an easier method has, therefore, to be prescribed. Hutchinson, Ramiah, *et al.* (1938) have published grades of hairiness of the stem-tip. It is now known that the stem-tip hairiness is closely associated with hairiness of the leaf. It is, therefore, proposed that the breeder should select, by visual observation only, plants of grades 1 and 2. If this is done a vast majority of the plants will be resistant to jassids.

SUMMARY

Jassid oviposition, hairiness and toughness were studied at Lyallpur during 1943, in all the plants of two hybrid progenies which were split for hairiness.

From the data obtained simple correlations between jassid oviposition, hairiness and toughness were worked out. The correlation between hairiness and toughness was positive and significant in both the progenies, showing thereby that hairy plants had tougher veins. The correlation between toughness and jassid population was significant only in the case of one progeny, therefore, its validity is rather doubtful. But it was negative in both the cases which shows that the jassid population had a tendency to decrease as the toughness increased. The correlation between hairiness and jassid population was negative and significant in both the progenies. This indicated that hairy plants had smaller populations and vice-versa.

The partial regressions were worked out from these three factors—jassid population, toughness and hairiness. The partial regression of hairiness and population, keeping the toughness as constant, was only significant and was a negative one. This showed, that out of these two plant characters, hairiness

played the major role in determining the extent of jassid infestation.

Jassid oviposition was also studied on shaved and unshaved leaves. It was seen that artificial removal of hair made no difference to jassid oviposition. It is, thus, evident that the physical presence of hairs does not induce resistance, though hairiness is closely associated with it.

It was further observed that plants having more than 120 hair per c.m. length of the leaf-vein had very little jassid population and hence may be considered as resistant. It is therefore recommended that the plant breeder should select plants having more than 120 hair per c.m. length of the leaf-vein. But as he is to deal with a very large number of plants in a limited space of time, it is not possible for him to actually count the number of hair. It is, therefore, proposed that the breeder should select plants, by visual observation, of grades I and II as described by Hutchinson, Ramiah *et al.*, (1938).

REFERENCES

1. AFZAL, M. AND ABBAS, M. 1943. Cotton Jassid (*E. devastans* Dist.) in the Punjab. V. A note on the characters of the plant associated with jassid resistance. Ind. J. Ent., 5, 41–51.
2. AFZAL HUSAIN, M. AND LAL, K. B. 1940. The bionomics of *E. devastans* Dist. on some varieties of cotton in the Punjab. Ind. J. Ent. 2, 123–136.
3. AHMAD, N., AFZAL, M. AND GHANI, M. A. (In press). An apparatus for measuring the toughness of leaf-veins of Cotton.
4. HUTCHINSON, J. B., RAMIAH, K. *et al.* 1938. The description of crop plant characters and their ranges of variation. The variability of Indian Cottons. Ind. J. Agri. Sci., 8, 567–591.
5. MACDONALD, D., RUSTON, D. F. AND KING, H. E. 1943. Progress report for the season 1942–43. Cotton breeding station Barberton. Prog. Rept. Expt. Sta. Emp. Cotton Gr. Corp., 18–36.
6. PAINTER, R. H. 1943. Insect resistance of plants in relation to insect physiology and habits. J. American Soc. Agronomy, 35, 725–732.
7. VERMA, P. M. AND AFZAL, M. 1940. Studies on the Cotton Jassid (*E. devastans* Dist.) in the Punjab. I. Varietal susceptibility and development of the pest on different varieties of cotton. Ind. J. Agri. Sci., 10, 911–926.